# Vegetation Resources Inventory

## Ground Sampling Data Collection Procedures for Inaccessible Samples

Prepared by
Ministry of Sustainable Resource Management
Terrestrial Information Branch
for the
Resources Information Standards Committee

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For further information about the Resources Information Standards Committee, please access the RISC website at: http://srmwww.gov.bc.ca/risc/.

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# 1. Introduction

## Objectives

The objectives of this document are:

- To define circumstances in which a sample location is considered inaccessible.
- To highlight how incomplete data caused by inaccessible sample locations affects VRI data analysis.
- To provide a way to ameliorate the bias associated with missing information due to the inaccessible sample location problems.

## Background

The Vegetation Resources Inventory (VRI) describes the type, amount, and location of vegetation in British Columbia. The general VRI process involves several phases:

- Photo estimation of polygon attributes
- Random sampling of a small number of these polygons
- Calculation of adjustment ratios between the photo-interpreted values and the ground "truth" data, which is then applied to all photo-interpreted values.

Managers, researchers, public and private agencies, and individuals rely on this information to evaluate present and future forest management options.

If such endeavors are to be successful, then the underlying ground sample data must be sound. One way to instill confidence in the inventory is to ensure that each sample selected represents known components of the target population. The sample must be representative of the population. A sample that does not represent the population will lead to biased inferences being drawn from the data.

When a sample size is determined for a target area and a sample is picked from a complete list of possibilities, statistically the sample represents the population. If for any reason every one of the selected ground sampling locations cannot be reached, the data become unbalanced and may no longer represent the population the way they should. In statistics, the condition where data are not available for a selected sample is termed a "non-response."

Over the past few years, several ways to sample non-response locations or to minimize their number have been explored. Potential options included:

- Use of specialty field sampling crews (such as a rappelling crew) to collect data on otherwise inaccessible sites.
- Collection of partial data sets using remote sensing methods.

- "Matching" similar accessible field sites to the non-response locations and completing data collection on the matched site.

The option chosen after much debate was the "matching" protocol in which similar sites are selected and sampled by a regular field crew. The bias of implementing such a protocol is unknown, but is expected to be low for the main timber attributes that are the primary driving factor of the sampling process.

## Causes of Inaccessible Samples in VRI

In British Columbia, the likelihood of encountering inaccessible samples in forest inventory is considerable. The VRI is intended to cover the entire forested land base regardless of ownership or access. Potential reasons for inaccessibility include:

- Plot locations within **dangerous, inaccessible polygons** containing steep cliffs and unstable slopes.
- Plot locations within **inaccessible portions of a polygon,** where rock bluffs, gullies, avalanche tracks or rock slides make access to the plot by regular field crews not possible.
- Plot locations inaccessible due to **excessive distance or lack of reasonable access**. For example, if it is impossible to get the crews to the plot location by all access means, including helicopters, and complete the sample within one day.
- Plot locations where **access is denied on private land.**
- Plot locations **inaccessible due to permanent danger to the crew.** (Samples temporarily inaccessible due to dangerous wildlife may be accessible later when the animal moves to a new location.)

To illustrate the magnitude of the issue, inaccessible samples within VRI ground sample projects from 1998 to 2001 are listed in Appendix A.

- Twenty-four samples were within dangerous inaccessible polygons with steep cliffs and unstable slopes. None of these samples were successfully matched.
- Twenty-nine samples were within inaccessible portions of an otherwise accessible polygon. Nineteen of these samples were successfully matched.
- Fourteen samples were inaccessible due to distance or lack of a reasonable access point. Thirteen of these samples were successfully matched.
- Five samples had denied access to private land. Four of these samples were successfully matched.
- No incidences of dangerous wildlife were encountered for the period covered.

The following table illustrates in general terms the magnitude of the issue regarding inaccessible samples:

| Region (Period) | Number of Locations | Proportion of Total Locations |
|---|---|---|
| Coastal area planned sample locations (1998–2001) | 791 | |
| Encountered inaccessible locations | 40 | 5.0% |
| Successfully matched locations | 10 | 25% |
| Range in proportion of inaccessible locations by project | | 0.0 to 13.6% |
| Interior area planned sample locations (1998–2001) | 2599 | |
| Encountered inaccessible locations | 33 | 1.3% |
| Successfully matched locations | 26 | 79% |
| Range in proportion of inaccessible locations by project | | 0.0 to 7.3% |
| Province-wide planned sample locations (1998–2001) | 3390 | |
| Total inaccessible sample locations | 73 | 2.2% |
| Total matched sample locations | 36 | 49% |

# 2. Objectives

The primary objective of the matching process is to select a substitute sampling site that is suspected of having minimal bias.

The "matching" process starts with selecting a site with the following attributes:

- A similar site within the polygon of interest,

or

- A similar site in an adjacent or locally adjacent polygon,

and

- A site that does not compromise field crew safety.

Selection of a "similar" site is based on the following criteria (in order of preference):

- Tree species composition
- Tree stocking
- Tree height, age, and crown closure
- Understory vegetation
- Other ecological factors, such as slope, elevation, aspect, and soil type.

These criteria will be discussed under "Detailed Procedures."

# 3. Detailed Procedures for Matching Inaccessible Samples

**Note**

1. These procedures apply (to a large extent) to the vegetated-treed component of the VRI. Thus, the criteria used to match inaccessible locations focuses on the attributes that influence the timber volume estimates. These attributes are emphasized because they play a key role in timber supply analysis. Procedures for non-vegetated and non-treed inaccessible sample locations are included to provide guidance on how alternative data can be collected for the non-timber locations.
2. The methodology used to find alternative information for inaccessible sample locations (matching) is based entirely on photo interpretation.

The procedures outlined here are based on those originally developed in 1998 to obtain original or alternative data to address the bias associated with inaccessible sample locations. The new methodology proposed to reduce the inaccessible location bias will not eliminate the bias completely, but will reduce the risk of bias to an acceptable (negligible) level.

## Vegetated-Treed Samples

Figure 1 shows a decision tree for deciding what to do when a sample is determined to be inaccessible. The matching procedures for collecting data are based on the decision tree.

### Step 1: Sample selection

The VRI Project Manager will select a list of samples for a management unit for field measurement.

### Step 2: Photo review of sample locations

The VRI Project Manager performs a preliminary assessment, using air photographs, of all sample locations.

If the photo review indicates a sample location that would be obviously dangerous and inaccessible, proceed to Step 7 and fill out a Non-Completion form and a Compass (CP) card.

If a number of samples are determined to be potentially inaccessible, the Project Manager may initiate a helicopter reconnaissance of all identified samples to verify the photo assessments.

## Step 3: Samples are assessed for reasonable access

If the photo review indicates a sample has no reasonable access point, proceed to Step 7 and fill out a Non-Completion form and Compass (CP) card.

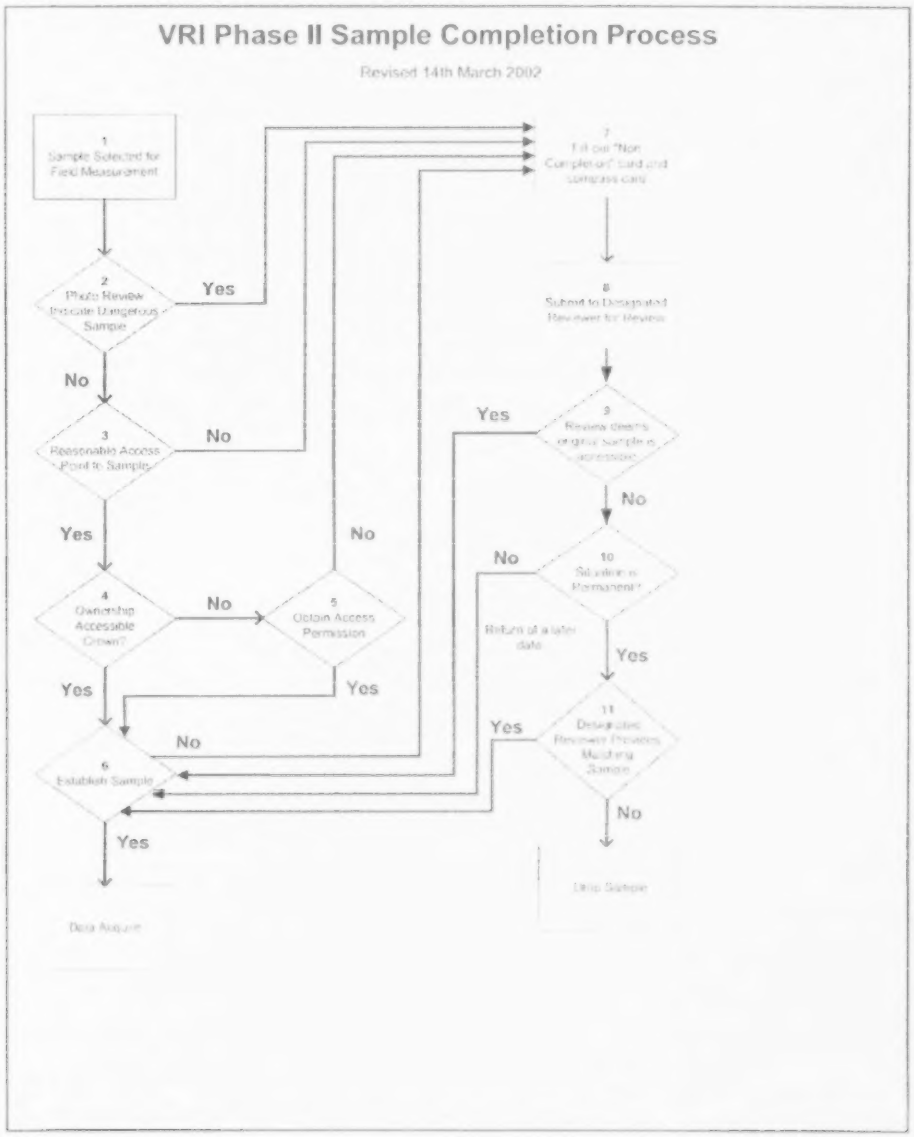


**Figure 3-1. Decision tree chart for evaluating and substituting inaccessible samples.**

## Step 4: Samples are assessed for land tenure

If the tenure review by the Project Manager indicates that the sample location is on private land, provincial parkland, or other alienated lands, a concerted effort must be made to obtain access permission (Step 5).

## Step 5: Obtain permission (or document denial) for private land samples

Obtain from the Land Registry Office the name, phone number, and address of the registered land owner. Contact the owner by phone and follow up with a letter or, if appropriate or necessary, with a personal visit.

Sufficient advance notice should be given the land owner or governing agency to allow for review and approval of the land access request.

If access permission is obtained, proceed to Step 6.

If access permission is denied, proceed to Step 7 and fill out a Non-Completion form and Compass (CP) card. Pertinent information regarding denied access or permission must be recorded on project file for the adjustment reporting process.

## Step 6: Field crew establishes the sample

A qualified field crew must establish all field samples.

In the field, some samples initially thought to be accessible may turn out to be inaccessible because of rock bluffs, steep gullies, or unstable slopes that prevent access to the sample Integrated Plot Centre (IPC). The crew may or may not be able to see the IPC from a safe location.

### Crew can get close enough to see the IPC

If the crew cannot get to the IPC, but can get close enough to see where the IPC would land, the crew should get a visual estimate of what is there, record the pertinent sample information as estimates, and use triangulation to get to the auxiliary plots if possible.

In a two-person crew, each crew member should independently estimate the location of the IPC and then determine an average for the two estimates.

For a complex site, the field crew should be able to get within 15 metres of the IPC. For a simple site, a greater distance is reasonable (for instance, a site that is 90% rock with minor vegetation could be assessed from a greater distance).

The field crew should document the reliability of their estimates. The sample is thus considered completed.

### Crew cannot see the IPC

If the crew cannot get close enough to see where the IPC would land, proceed to Step 7 and fill out a Non-Completion form and Compass (CP) card.

## Step 7: Documenting inaccessible samples

The group of all samples that cannot be measured initially constitutes the "population" of inaccessible samples. The Project Manager or project team will, by this time, have explored all viable options to complete the samples (such as returning to complete the data collection after a temporary hazard is removed). For each of the uncompleted samples, the Project Manager or field crew must complete a Non-Completion form and a Compass (CP) card and add it to the original sample package.

## Step 8: Requesting a matching sample

The Project Manager or field crew submits the entire package to a qualified reviewer with a request for a matching sample location.

### Documentation package

In 1998, preliminary "matching" procedures to address data collection for inaccessible samples were introduced. Since then, documentation associated with samples that could not be accessed for any reason has been submitted to the Terrestrial Information Branch for "matching" accessible samples.

The submission package must clearly document the reasons why the sample was considered inaccessible and must contain the following information. This information package will be prepared by the Project Manager and will usually be reviewed by the Regional Ministry of Sustainable Resource Management service centres.

- A large-scale map clearly showing the location of the polygon being sampled and the Integrated Plot Centre (IPC).
- A forest cover map highlighting the polygon being sampled, with the IPC located and marked.
- A photo pair with the sample IPC clearly and accurately located and marked.
- A comment on the form shown in Figure 2 indicating whether an air or ground reconnaissance had been done to determine accessibility. This would eliminate any discrepancy about the level of accessibility.

## Step 9: Assessment by qualified reviewer

The reviewer conducts a review of the sample in question. If the reviewer disagrees with the initial assessment that the sample is inaccessible due to excessive distance or lack of a reasonable access point, the request for a matching sample will be rejected, and the crew will be advised to establish the original sample. The reviewer may assign a different crew to collect data from such a location.

## Step 10: Temporary or permanent inaccessibility

If the cause of inaccessibility is not permanent (e.g., a wildlife encounter), the crew will return to establish the original sample after the threat is gone.

If the cause is permanent (e.g., steep, unstable slopes, cliffs, or no reasonable access points), proceed to Step 11 and obtain a matching sample.

## Step 11: Matching the VRI sample location

The reviewer will provide a matching sample location and alternate matching locations for the field sampling crew if possible. If no suitable matching site can be found the sample will be dropped. The sample matching process is explained in the following section.

### Criteria for selecting matching samples

Several criteria are used to determine if a substitute site is well matched with the IPC of an inaccessible sample. The matching process will, in most cases, be based on photo interpretation at a scale of approximately 1:15,000. The sites should be matched as closely as possible using the following criteria and priority.

Criteria 1 and 2 must be accomplished to achieve a successful match. Criteria 3 to 5 are desirable, but should not prevent a match if the first two criteria are achieved.

1. **Similar leading species composition:** The species composition for the substitute site should be similar to the original sample cluster location. The species composition of the polygon will not necessarily be the same as that near the grid intersection where the 5-plot-cluster is established. The interpreter should estimate a "new" species composition for the area surrounding the intended IPC, and use that composition to search for the matching site.

2. **Similar stocking:** Matching sites should have a basal area for trees similar to the original site. Photo interpreters who undertake the matching should use standard photo-interpretation templates to estimate the basal area to achieve this criterion. An exact match may not be achievable for two random locations in the forest, but the matching site should be within 10% of the basal area for the original site.

3. **Similar the tree heights, average age, and crown closure characteristics:** These characteristics for the substitute site should be similar to those of the original sample location. Height, age, and crown closure are key attributes in determining stand volume for a given species. If one of these attributes must be ignored, of the three, crown closure has the least influence on variation in volume. Crown closure is closely related to the determination of number of stems per hectare, so it may not make much difference if it is not used in the matching.

4. **Similar understory:** The understory for the substitute site should be similar to that of the original sample. This criterion relates to the ecological information that could be obtained from the shrubs, mosses, grasses, lichens, and similar vegetation under the canopy. This information is very useful for ecologists, but may not be highly correlated with timber volume. A higher priority should be placed on obtaining a substitute site that yields similar volume to the original inaccessible site.

5. **Similar slope, aspect, elevation, and soil type:** Other factors should be considered, but are not necessarily critical to the matching process.

   Earlier trials of the matching process placed higher emphasis on slope than was required. Matching a steep slope with an equally steep one is not the intent of the matching; matching similarity in vegetation and, in particular, in volume is of high importance. If an inaccessible, steep slope is encountered, but similar vegetation can be found on a less steep slope, the less steep site should be accepted as a substitute for the steep location.

A similar argument applies to elevation and aspect. The elevation and aspect of an inaccessible sample location does not have to match those of the substitute site exactly. This does not mean that slope, aspect, and elevation are not important, but the highly precise constraints around those factors will make the matching process virtually impossible to accomplish.

Meeting the requirements of the first two criteria should be the minimum, but it should be possible to meet these criteria and still find matches for most inaccessible sample situations. Dangerous Plots pose the biggest challenge, but if the emphasis is moved away from matching steep slopes with equally steep ones, it may not be as difficult to find reasonable substitute sites.

**Procedures for matching samples**

The following procedures should be used to find matching location(s) for an inaccessible VRI sample location:

1. Obtain a stereo pair of the document photo that shows the original sample location.

2. Obtain two additional stereo pairs on the same flight line — one before and one after the main stereo pair.

3. Examine the IPC identifying the inaccessible sample location.

4. Record a description of the tree species, stem density, tree height, and estimated age of trees at the inaccessible location on the Inaccessible Sample Form (Figure 2). This description should be of the selected random point within a VRI sample polygon, not the map polygon stand description.

5. Use the description to search on the main stereo pair for alternative locations with the same stand description as the inaccessible sample. At a minimum, the matched plot must be in the same stratum as the inaccessible plot. So if the stratification is on the basis of spO or ITG, this must be matched. Likewise, if there is any stratification on the basis of maturity or operability, this must also be matched.

6. Start the search for an alternative location in the polygon where the inaccessible location was found.

7. Search outward from the original sample polygon and extend to the edges of the stereo pair of the document photos.

8. If a search in the vicinity of the original VRI sample polygon (as described in 6 and 7) fails, then use the forest cover map to locate polygons with attributes the same as or similar to the original sample polygon, and view the photos of these polygons to locate a matching sample.

9. If a match is not found on the main stereo pair of document photos, continue to search on the left adjacent stereo pair. If there is no match on the left stereo pair, search the right pair.

10. When a matched site is found, fill in Column 3, "Description of the Matched Site," on the Inaccessible Sample Form (Figure 2). Use one form for each potential substitute site. The descriptions allow you to compare what is at the inaccessible location with what is at the matched site. If suitable matching attributes are found in a stand, mark the area best matching the original IPC directly on the air photo. If the matching sample is potentially dangerous to access, provide alternatives numbered in a priority order. Provide approximate bearings and distances from the original IPC for the proposed matching samples.

11. File the form as part of the regular VRI data collection documentation.

12. Return the original sample package, the completed Inaccessible Sample Form (Figure 2), and the marked document photos identifying the matched location(s) to the Project Manager to have the sample established as per Step 6 under Procedures for Matching Inaccessible Samples.

13. If a matching sample cannot be found, the sample is dropped and a record is put on file.

## Non-Vegetated and Non-Treed Samples

For samples that are inaccessible but fall on non-vegetated or non-treed land, "ground" data may be collected by unconventional means.

This category includes samples that fall on:

- Glaciers
- Bare rock
- Talus slopes with active rock falls, or shifting sand
- Inaccessible grass or shrub sites

Obtain accurate information for these inaccessible samples by a remote-sensing method, such as 70-mm photography or digital/video camera. At the moment, 70-mm photography is the most promising because it has been in use for some time and no experimental testing would be required to apply it operationally.

**Inaccessible Sample #:** 27 **Project** _____

(one substitute sample location per form)

| Attribute | Estimates at Inaccessible Location | Description of Matched Site | Comments |
|---|---|---|---|
| BEC | IDF | IDF | |
| Species composition | Fd 60, Pl 20, At 20 | Fd 50, Pl 45, At 5 | Less aspen on general site than original sample location |
| Basal area | 25 | 30 | |
| Tree height | 23 | 25 | Tree heights more variable on matched site |
| Estimated age | 130 | 120 | Ground call age near matched site but no data near original location available |
| Crown closure | 75 | 80 | |
| Estimated slope | 110% | 90% | |
| Aspect | SW | SSW | |
| Elevation | 1150 | 1100 | |
| Other | | | |

**Figure 3-2. Inaccessible Sample Form for recording a description of an inaccessible VRI sample location and the matched site.**

## Samples with No Suitable Matches

Some managers of the VRI implementation have asked: *Is there a threshold number of inaccessible sample locations that would be considered acceptable?*

An attempt should be made to find matches for **all inaccessible sample locations.** Even if only 1 location of 300 is found to be inaccessible, an attempt should be made to find a match for it.

However, **only one attempt should be made** to find a matched location. If the first matching site is also found to be inaccessible, no further effort should be made to find a second match. This rule has been introduced to make the matching process more cost efficient, and to avoid situations where several matching attempts fail to find an accessible location.

The question then is: *If this happens at more than one location, what proportion of locations can be dropped without introducing significant bias?*

An arbitrary limit of 5% dropped locations in a series has been set as acceptable. This tolerance limit should be explored only after all possible efforts have been made to reach matching sites.

## Ground Data Collection

After the matched site has been identified, the new site should be visited on the ground to collect measurement attributes. Follow the same procedures as for regular VRI sample locations. The only difference is that the sample type is identified as "M" under Character 2 of "Plot Type" on all the field cards.

Detailed ground data collection procedures are provided in the "Vegetation Resources Inventory Ground Sampling P·ocedures" manual, which is available online at http://srmwww.gov.bc.ca/tib/veginv/publications.htm

## Code "M" for Inaccessible Samples

For compilation purposes, the Project Manager will ensure that all field cards for inaccessible sample locations are identified by the special data type code "M" under Character 2 of "Plot Type." This identifies the data set as being a "Matching" sample. This code will be the only unique feature of the inaccessible data capture forms, otherwise the standard VRI data capture forms are used for all aspects of inaccessible data collection.

Record the UTM co-ordinates of the matched location on the Compass (CL) card 3. Record the original design UTM co-ordinates under "Comments" on the same card.

The standard VRI data capture forms should also include documentation on why the ground sample was considered to be inaccessible when the initial cruiser attempted to visit it. Use the form shown in Figure 3.

**VRI GROUND SAMPLE - RECORD OF PLOT NON-COMPLETION**

**(to be filled out for any plot that cannot be established)**

| | |
|---|---|
| Sample # | 27 |
| Map sheet | 92 H 078 |
| Polygon # | 568 |

| | |
|---|---|
| Crew | John Smith |
| Date | July 12, 2003 |
| Project | TFL 234 |

Why the plot cannot be established (check all applicable boxes)

- [x] Access to plot is too dangerous
- [ ] Plot would be located in an unsafe area
- [ ] Plot would be located in river or lake
- [ ] Permission denied to access private land
- [ ] Other, specify:

Detailed comments:

**Figure 3-3. Record of Plot Non-Completion form to document the reason(s) for failing to reach a targeted sample site.**

# Appendix A: Summary of Inaccessible Samples To Date

**Projects Completed 1998 – 2001***

***(source of data: MSRM regional staff)**

| Region | Project Title | Planned # Samples | # & type of Inaccessible [1] | # Successfully Replaced | Unsuccessful Replaced/Drop | Samples Completed |
|---|---|---|---|---|---|---|
| Vancouver | DSC Sunshine Coast | 169 | 13 dp; 5 ds; 5 pl | 4 pl; 1 ds | 13 dp; 4 ds; 1 pl | 156 |
| | TFL 25 bk1 1998 | 130 | 2 ds | 0 | 2 ds | 126 |
| | TFL 25 QCI 1999 | 80 | 3 dp; 2 ds | 1 ds | 3 dp; 1 ds | 75 |
| | Chilliwack River LU | 40 | 3 dp | 0 | 3 dp | 35 |
| | TFL 45 Knight Inlet | 40 | 1 ds | 1 ds | 0 | 39 |
| | TFL 37 2000 | 95 | 4 ds | 3 ds | 1 ds | 80 |
| | Fraser TSA 1999 (IFPA & non IFPA) | 137 | 0 | 0 | 0 | 175 |
| | TFL 6 | 100 | 2 dp | 0 | 2 dp | 98 |
| Kamloops | Lillooet [started] 1999 | 193 | 11 nra + 3 dp | 11 nra | 3 dp | 186 |
| | TFL 49 | 87 | 0 | 0 | 0 | 85 |
| | Adams Lake IFPA | 85 | 0 | 0 | 0 | 76 |
| | Merritt FD / IFPA | 125 | 0 | 0 | 0 | 125 |
| | TFL 15 | 74 | 0 | 0 | 0 | 74 |
| | Kamloops TSA | 48 | 0 | 0 | 0 | 48 |
| Cariboo | Williams Lk TSA | 333 | 3 nra | 2 nra | 1 nra | 332 |
| | 100 Mile TSA | 37 | 0 | 0 | 0 | 37 |
| | Lignum IFPA | 363 | 0 | 0 | 0 | 363 |
| Nelson | Boundary TSA | 150 | | | | 160 |
| | TFL 3 | 90 | 1 | 0 | 1 | 90 |
| | TFL 23 | 314 | 13 ds | 11 ds | 2 ds | 289 |
| | Arrow FD / Lemon Ck LU | 20 | | | | 18 |
| Prince Rupert | Babine IFPA | 80 | 0 | 0 | 0 | 80 |
| | TFL 1 | 150 | 0 | 0 | 0 | 150 |
| Prince George | PG south | 113 | 0 | 0 | 0 | 113 |
| | TFL 30 | 267 | 2 ds | 2 ds | 0 | 267 |
| | Vanderhoof IFPA | 70 | 0 | 0 | 0 | 70 |

1 - Types of inaccessible = dangerous inaccessible polygon (dp); danger slopes within accessible polygon (ds); private land (pl); no reasonable access (nra); wildlife (w)

| Region | Project Title | Planned # Samples | # & type of Inaccessible [1] | # Successfully Replaced | Unsuccessful Replaced/Drop | Samples Completed |
|---|---|---|---|---|---|---|
| | **Summary** | | | | | |
| | Projects with dp = 550 samples completed & 24 dropped = 4.4% dropped; 0% successful match. | | | | | |
| | Projects with ds = 1283 samples completed, 29 with ds = 2.3%, 10 dropped = 0.8%; 19 success match = 1.5% | | | | | |
| | Projects with nra = 518 samples completed; 14 with nra = 2.7%; 1 dropped = 0.2%; 13 success match = 2.5% | | | | | |
| | Projects with pl = 156 samples completed, 5 with pl = 3.2%; 1 dropped = 0.6%; 4 success match = 2.6% | | | | | |
| | Projects with w = 0 | | | | | |

# Appendix B: Record of Plot Non-Completion Form

**VRI GROUND SAMPLE - RECORD OF PLOT NON-COMPLETION**

**(to be filled out for any plot that cannot be established)**

| | |
|---|---|
| Sample # | |
| Map sheet | |
| Polygon # | |

| | |
|---|---|
| Crew | |
| Date | |
| Project | |

Why the plot cannot be established (check all applicable boxes)

- ☐ Access to plot is too dangerous
- ☐ Plot would be located in an unsafe area
- ☐ Plot would be located in river or lake
- ☐ Permission denied to access private land
- ☐ Other, specify:

Detailed comments:

# Appendix C: Inaccessible Sample Form

**Inaccessible Sample #:** _____ **Project** _____

(one substitute sample location per form)

| Attribute | Estimates at Inaccessible Location | Description of Matched Site | Comments |
|---|---|---|---|
| BEC | | | |
| Species composition | | | |
| Basal area | | | |
| Tree height | | | |
| Estimated age | | | |
| Crown closure | | | |
| Estimated slope | | | |
| Aspect | | | |
| Elevation | | | |
| Other | | | |

# Appendix D: Frequently Asked Questions

Answers to frequently asked questions regarding inaccessible samples may be useful to those who want further clarification of the principles behind the procedures.

**Q: Why aren't "substitute" sample locations chosen randomly from existing potential polygons?**

A: The key objective of the inaccessible sample procedures is to capture information on unique components of a target population that may otherwise be missed if equivalent data were not obtained. Random substitution would not seek out the unique data resembling what is at the inaccessible location, thus the results of the sampling process would be biased. The matching process is an attempt to capture the unique conditions at difficult-to-reach locations, and thus to reduce the bias associated with inaccessible sample locations.

**Q: What happens during sample data analysis if no matches are found for a small proportion of the planned locations?**

A: Assuming the planned sample was allocated proportionally to a number of strata in the target population, inaccessible samples in some strata would upset the proportional representation. For this reason the area covered by each stratum should be divided by the achieved sample size in the strata to obtain new sample weights. In proportional allocation, those weights would be equal for all strata.

**Q: How many inaccessible sample locations are required to cause a significant bias in the inventory information?**

A: In principle, the ground sample data should be totally free of any bias. Any missing information resulting from a failure to visit all planned locations compromises that principle. For this reason, all planned locations or matched locations should be visited in order to minimize bias. However, in some situations, it may be impossible to obtain 100% matching of all inaccessible sample locations. Therefore, an arbitrary 5% tolerance limit is set: in difficult situations, the idea of dropping 5% of the planned samples is acceptable if no suitable matches can be found.

**Q: What is the magnitude of bias that results from sample location inaccessibility?**

A: The magnitude of bias associated with inaccessible sample locations varies with the type of inventory unit and the causes for inaccessibility. No literature has been found to assist in providing generalized estimates of the magnitude of bias.

**Q: Can the bias be reduced by increasing the planned sample size if it is anticipated that some locations will be inaccessible during ground sampling?**

A: This is a common practice in social studies where prior information on the target population is easily available. In forest sampling, however, the main cause of

inaccessibility of sample locations is the physiographic characteristics of the location. In most cases, there is a link between physiographic and vegetation characteristics. Therefore, increasing sample size will not eliminate the presence of a number of locations that are difficult to get to due to topographic features.

Q: **If the VRI ground and photo-interpreted data are being used to build adjustment relationships, is there any evidence to show that those relationships are different if the inaccessible (matched) data is ignored as opposed to when it is included?**

A: If the VRI data is being used for one purpose only (for example, to build adjustment relationships), it might make sense to investigate the effect of eliminating the data from the matched locations. However, the VRI data will be used for many other purposes. For instance, planners might want to compare the average volume for sample observations collected in one period to those collected in another period. For this comparison to be valid, the average volumes for the two periods should be unbiased. If there is bias in one or both averages, then it is difficult to tell if the difference between the averages for the two periods is small or large. The bias in the averages masks the real differences, so addressing the inaccessible sample locations problem is still necessary.